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MECHANICAL JUMPING POWER IN ATHLETES

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ABSTRACT

The Wingate cycle ergometer test is a widely used test of sustained muscular power. A limitation of the test is the lack of development and retrieval of stored elastic energy due to a lack of an eccentric phase. To measure mechanical power output of the entire stretch-shortening cycle, the test of Bosco et al (1983) was administered to 119 male athletes in 7 different activities during their pre-participation evaluations. The sports tested were indoor soccer, American football and ballet (professionals), outdoor soccer, basketball and wrestling (collegiate) and amateur bobsled. Results showed the overall average power output to be 20.37 W.kg^{-1} for the 60s reciprocal jumping test. Ballet dancers generated significantly less mechanical power than indoor soccer, basketball and bobsled athletes, while wrestlers generated significantly less power than indoor soccer and basketball athletes (all $p < 0.05$). No other between-sport differences were seen. A subset of indoor soccer players ($n = 10$) were retested after 4 months of training. Power improved from 20.8 to 24.3 W.kg^{-1} ($p < 0.05$). While between sport differences were limited, training differences in one subset of athletes were readily identified.

Key words: Mechanical power, Muscle mechanics, Exercise test

INTRODUCTION

The assessment of the various aspects of fitness is a common occurrence in the sport science laboratory. Parameters most commonly measured include maximal oxygen consumption, as a measure of aerobic fitness, and body composition, as a measure of physique. Anaerobic power, while a necessity for many sports, has been investigated to a lesser degree. Validity and practicality questions are frequently cited. Typical measures of anaerobic fitness have included oxygen debt, blood lactate, vertical jump, stair climbing activities and the Wingate cycling test. Two limitations are usually evident. First, the vertical jump and Margaria test are single measures of explosive power and say little about the person's ability to sustain a high power output. Finally, the Wingate test studies power output over time using cycle ergometry.

A description of a field measure of the mechanical jumping power was described recently (Bosco et al, 1983). This test required the subject to perform vertical jumps continuously with maximal effort for n seconds recording flight time and jumping frequency. This test considers the 2 limitations described above. It looks at the ability to sustain power output for a period of time and the use of stored elastic energy as a contributor to the total power output. The authors considered the test to have high reliability ($r = 0.95$). The test was also significantly correlated with the Wingate test ($r = 0.85$ for a 15s test and $r = 0.80$ for a 60s test).

The original article described data for male school boys (mean age = 17), volleyball (mean age = 22) and basketball players (mean age = 24). They described values of 22.2, 21.5 and 19.8 W.kg^{-1} respectively for a 60s test. In an attempt to expand the data base, a wide variety of athletes were assessed during their pre-participation physical examinations. In addition, a small subset of athletes from one team were retested during their competitive season to look for training adaptations.

METHODS

Professional and amateur male athletes were assessed during their pre-participation physical examinations. Physical characteristics of the athletes are listed in Table I. The test of mechanical jumping power (Bosco et al, 1983) was administered to those athletes without musculoskeletal limitations and a random group of professional American football players.

TABLE I

Age and weights by team. Mean (S.D.)

Team	N	Age	(Yrs) ±	Weight	(Kg) ±
Professional Ballet	12	25.4	(4.9)	69.5	(8.6)
College Wrestling	24	19.7	(1.4)	74.7	(11.0)
Professional American Football	19	23.6	(1.9)	96.7	(16.2)
College Soccer	19	19.9	(1.4)	71.8	(8.5)
Professional Indoor Soccer	22	26.4	(4.6)	74.4	(6.6)
Amateur Bobsled	7	31.7	(7.1)	86.0	(12.2)
College Basketball	16	19.9	(1.6)	84.5	(11.0)

This test required the subjects to perform the maximal rebound jumps as rapidly as possible. In both the referenced and the current studies, the test was 60s in duration. A 90 degree knee bend between jumps and hand placement on hips was the standard form. The Dekan Automatic Performance Analyser (Carol Stream, IL) was used to record flight time. Two switch mats for the timer were placed side by side and connected by a "Y" adapter to the timer ("start on break contact" input). The "special start" hand switch had to be used. This switch was an enabling switch for the circuitry at the start of the test and a genuine stop switch at the end of the test. Jumping frequency was visually counted and recorded manually by one tester. The mats each have a 2 inch border that does not register on the timer. To minimise "dead spots" the central 2 inch borders were removed from the timing mats. The reliability of the test has been published at 0.95 (Bosco et al, 1983).

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Standard descriptive statistics, univariate analysis of variance with 1 grouping factor (team) and repeated measures analysis of variance with 1 repeated factor (period of training) was applied to the data. The t-test procedure for unequal group sizes was used to follow up significant F ratio (Dixon, 1983). Differences were considered significant at the 5 per cent level.

RESULTS

The results for the 60s test are presented in Table II and are similar to those previously reported (Bosco et al, 1983). Professional ballet dancers generated less power than subjects competing in indoor soccer, bobsled and basketball ($p < 0.05$). Collegiate wrestlers generated less power than indoor soccer players and basketball players ($p < 0.05$). Table III presents a matrix of significance levels. In general, the results for team sports were similar to each other.

TABLE II

Mean values for mechanical jumping power ($W.kg^{-1}$) by sport

	Mean	S.D. ±
Professional Ballet	18.08	2.15
College Wrestling	18.62	3.16
Professional American Football	20.8	3.81
College Soccer	20.90	3.51
Professional Indoor Soccer	21.50	4.17
Amateur Bobsled	21.86	7.54
College Basketball	22.22	5.83
OVERALL	20.37	4.20

TABLE III

Matrix of significance levels for average power output during the jumping test by team

	1	2	3	4	5	6
1) Professional Ballet	—					
2) College Wrestling	0.71	—				
3) Professional American Football	0.07	0.08	—			
4) College Soccer	0.06	0.07	0.96	—		
5) Professional Indoor Soccer	0.02	0.02	0.64	0.64	—	
6) Amateur Bobsled	0.05	0.07	0.57	0.59	0.84	—
7) College Basketball	0.02	0.03	0.41	0.42	0.66	0.86

A subset of indoor soccer players were retested after 4 months of their professional season. The calculated power results (20.83 ± 3.25 and 24.35 ± 3.86 $W.kg^{-1}$ pre- and mid-season respectively) were significantly improved ($p < 0.05$).

DISCUSSION

The test design measures power output from chemical or mechanical origins. The differences in mechanical power output between this and other tests has been previously discussed (Bosco, 1983). It is recognised that some energy is stored in the elastic component of muscle during the eccentric portion of selected movements (Komi, 1978). Cycling has little, if any, eccentric component. As such the Wingate test is appropriate for studying muscle power without the effects of energy stored in the elastic component of muscle. Specificity calls for the Wingate test to be used as a test of anaerobic power especially for cyclists and possibly speed skaters. In activities with an eccentric component, like jumping, where decleration and changes in direction occur, the measurement of stored elastic energy would be helpful in evaluating muscle power. It does appear that this test is better suited to study sports that require the entire stretch-shortening cycle, which encompasses a wide variety of activities.

All of these tests were performed during the pre-season physical evaluation before formal training had begun, typically in August or September. The training which preceded all but the wrestlers (who did not begin formal training until November) and ballet emphasised higher intensity work to be able to accommodate upcoming sport specific training. The wrestlers were tested during a period that emphasised weight maintenance and aerobic training while the ballet was measured during a period that emphasised weight maintenance and flexibility. It is possible that off season training influenced the results.

To see if sports-specific training would have an effect on power output, a small subset ($n = 10$) of professional indoor soccer players were retested 4 months later during the middle of their season (Table IV). Their training was regular fitness and tactical training associated with their profession. Thus, while no special training was used by these athletes, the demands of indoor soccer (Kirkendall, 1985) resulted in a 17% improvement in mechanical jumping power. Eighteen months of "specialised elasticity" training for volleyball players improved single (not rebound) vertical jump by 12% (Komi, 1979).

In conclusion, mechanical jumping power as measured by the method of Bosco et al (1983), was determined on 119 male athletes during their pre-season evaluation. The group mean was 20.37 $W.kg^{-1}$ which was consistent with the original report. Between-sport differences were limited. Most of the subjects were team sport athletes and generated similar power values. Training adaptations were measurable as indicated by the 17% improvement in mechanical jumping power in professional indoor soccer players.

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